National 12 Amateur Boat Building Guide

Introduction

AMATEUR ....

“One who cultivates any study, art or sport for the love of it and not for the money.”

[NEW OXFORD DICTIONARY]

1st revision	1978	Andrew Turner
2nd revision	2004	Graham Camm

1. INTRODUCTION

The whole essence of a development class is that by individual approach we may steadily progress with the times. There are however a number of general questions that the first time builder invariably asks regarding possible methods of construction and therefore these notes are an attempt to lay a basic foundation, one that can be embellished by an individual approach as the work progresses.

There are now several methods which can be used to build a National 12: there are two methods still used in wood (ply planked and strip cedar) and there are two method of foam construction (building on a male mould or female mould). This guide also include details of older construction methods (planked, and cold moulding), which make an interesting read and if you want to make a boat in character then the information is all here. The methods each have their merits; for example, stripped cedar is good for a one or first off design as it is easy to shape around frames, foam construction will produce the lightest hull but needs a mould to get good results while ply construction is probably the cheapest but heaviest (but amateur boats can still be built down to the minimum weight using this method).

This section provides an overview of methods and designs, please download the other packs for details about the different methods.

There are three questions that any prospective first time builder often asks: how much will it cost, how long will it take and can I do it in my front room?

1.1 Cost

Item	Options	Price range (£)
Hull Materials & Consumables	Wood	500-1000
	Glass – foam – epoxy	1000-1800
	Carbon – foam – epoxy	1800+
Paint / varnish/ hibuild		200-300
Boom (homemade)	Carbon	100
Rudder (homemade)	Cedar, glass, carbon	150-200
Centreboard (homemade)	Cedar, glass, carbon	150-200
Mast (professionally built*)	Carbon	700-1000
Sails	Dacron, Mylar	600-900
Fittings		600+

homemade only if feeling very confident

The major saving over the cost of a professional boat is in the hull, but do remember that no consideration has been given to the man hours involved. The variations in the quoted prices are to take into account the differing prices from individual manufacturers, (sails, masts and fittings) and personal taste. If you think the professional boat builders are making a tidy profit, then hold the thought until you've built your boat.

1.2 Sourcing materials

It is recommended to investigate a wholesale stockist who should offer a bulk buying discount as buying material from a normal chandlery can get a bit pricey.

- Foam and epoxy: MarineWare (02380) 330208 www.marineware.com
- Wood: Robbins Timber of Bristol. Tel: 0117 963 3136. www.robbins.co.uk

1.3 Time

Building is labour intensive and as the main source of labour is you, the reader, the question is how fast do you work and how many hours can you afford to put aside for boat building? It roughly takes 150 to 250 hours to make a boat plus painting and fitting out. Typically allow twelve weeks for hull work, two weeks for painting and three weeks for those last minute items like fitting out and planning the next boat. Amateur builders are all alike when you talk to them, stories of why something does not look quite right and how it will all be corrected in the next one. The deciding factor is really the standard that you are willing to accept and are trying to achieve.

1.4 Space

A workshop around 22' x 14' is a good size, 14[1] x 8' is the minimum. The floor must be reasonably flat as the shape of the finished boat will rely on the accuracy that the frames have been erected with. The lighting must be good; you cannot build a boat with one 40 watt bulb hanging from the roof. There is no substitute for daylight but as most amateur boats are built in the winter there is no choice. Heating is important when bonding: localised heating can be arranged fairly easily to aid glue curing. With carbon / glass fibres it is best to choose somewhere away from the house as the dust and strands of cloth tend to follow you around.

1.5 Health & Safety

Thinking about health and safety is vital when working with carbon fibre and epoxy resins. Wearing safety glasses and a breathing mask (for dust and fumes) when cutting or sanding is recommended. When working with epoxy resin apply a barrier cream and wear latex gloves to avoid skin reactions. Keep the place well ventilated and don't forget to read the manufacturer's notes and warnings

1.6 Tools & equipment

Lots of clamps (some pretty large)
Jigsaw
Hand saw
Long steel ruler
Spirit level
Good pair of scissors or shears for cutting cloth and peel ply
Mixing pumps are great for small quantities of epoxy
Power sander
Lots of coarse sand paper and some long pieces of wood to get a smooth curve
Set square
Filleting sticks
. . . and much more

2. Choose a hull design

This is one area which the amateur has usually decided on prior to building. If you are in doubt then I would suggest that you look at the respective success of the design which most appeals. Do bear in mind that each boat is designed to carry a certain weight and for certain conditions. That leaves us with three basic methods of going about the building process.

2.1 Borrow a mould.

By doing this it is possible to build to a proven design and someone else has done all of the initial work for you. It should also be possible to see the finished boat that came from the mould in question and therefore you will get a good idea of the accuracy with which the initial frame sections were constructed. The moulds do of course have a limited life depending on the way they are treated.

2.2 From a designer's plans.

This was a common method for planked construction. The amount of information contained on the designer's plans is usually limited to either a table of offsets for the hull, or drawn on a single sheet. The sections, whether in graphical form or tabulated, are to the outside of the skin and so allowance should be made for the plywood thickness.

2.3 Design your own Boat.

Assuming that you have the knowledge and faith in yourself to design your own boat then it is a safe bet that you do not require the help of notes such as these. Here's an edited version of some notes from John Wills. C. Eng.. M.R.I.N.A.

"Many eminent people and lesser mortals have attempted the design of National Twelves, and many have got it wrong. As with most matters concerning marine design, especially sail craft, that which pleases the eye by line and shape usually turns out to be more successful than the clinical mathematical approach. Naval architecture is an art fully assisted with all the modem electronic tools. A great deal of work has to go into any design proposal before it sees the light of day, the following will have to be calculated: displacement (fully crewed), centre of buoyancy, centre of gravity, balance, hydrostatics, and maybe basic tank testing. Sail plan and centre of effort and centre of lateral resistance will need to be calculated.

The designer first starts off with his basic sketch, runs the lines in sheer and plan, runs waterlines, bow and buttock lines and diagonals and roughly fairs in everything. He then produces his first shots of centre of gravity and buoyancy. This process continues in draft until the designer is sure that the balance has been obtained. His next step is to the loft floor where the design is drawn out full size in three planes, and fully faired in, these are sheer plan, waterline plan and front sections all three must be compatible. From this the designer prepares a table of offsets, a numerical set of figures, from which a scale drawing can be accurately produced- From the table of offsets, final checks of all the main statistics can be made."

This is the mechanics of the hull design. However, here are a few thoughts on designing a National Twelve. As designers we are initially faced with several restraints of the National Twelve hull rules and dimensions. The aspiring National Twelve owner is looking for the design which will win races on all types of waters and possibly the Burton. A boat which meets these criteria is probably impossible to design. The initial step is to ascertain on which type of water the boat will spend its maximum time. Boats for sea and lake work usually require quite different hull forms from those used mainly on rivers. Taking the latter type first: this boat will require good windward characteristics, the ability to manoeuvre and tack quickly and have excellent off-wind and running performance in non-planing conditions. This design will therefore, require:

? A very fine entry with narrow "V" sections forward and almost parallel straight waterlines forward to reduce wave-making resistance forward.
? Very low wetted surface area.
? Sufficient rocker on keel forward to assist tacking (nil rocker can make this difficult at times).
? Sufficient rocker aft to keep the transom clear of the water when in the normal trim to minimise transom drag. Waterlines will therefore need to be as fair as possible and gently swept in aft, and buttock lines aft almost parallel and also fair aft.
? Beam almost to maximum for power on windward legs.

The above should give good performance under non-planing conditions due to its low wetted surface area, but would result in a fairly tender boat. Sail plan should be the highest aspect possible with a smallish foresail.

Boats for sea conditions require a very different approach in design to be successful in the conditions usually met at sea, that is, they should be capable of good performance under fairly heavy wave conditions. To this end, buoyancy considerations, especially forward need to be carefully worked out. and of course the entry needs to be reasonably fine. "U" hull cross sections appear to meet the requirements allowing reasonably fine waterlines whilst giving the necessary buoyancy forward for heavy sea conditions. Off wind performance in planing conditions is necessary, so the aft sections require to be relatively flat. However, it should be stressed that transom immersion should be avoided because of drag considerations. Beam again should be at a maximum for windward power. The sail plan should be lower aspect ratio with the foresail being 25-28% of the total sail area.

There is a wealth of talent in the class membership who will no doubt be very pleased to be consulted on specific points, and who knows, may just achieve the breakthrough we are all looking for in the future design for the class.

3. Creating a mould or frames

Whatever form the designer's plans take, the object is to accurately translate the plans into a usable mould from which the boat may be built. Time spent on this part of the operation will be rewarded by the fairness and symmetry of the finished boat. The frames can be made out of MDF or cheap ply wood attached to a substantial floor frame made from 3" x 2" softwood, the two side members are just short of twelve feet long and these are separated by 3" x 2" cross members at the frame stations. The usual frame Transom spacing is as follows:, 2', 4', 6', 7'6", 8'9" 10'6", 11'10 ½ " (apron). All cross-members have plywood gussets for strength and all frame stations are marked for clarity with felt tip pen.

Whenever a new design is undertaken a new set of frames or transverse sections are made and these are set up on the existing floor frame.

You do not of course have to make a frame section for the transom, bulkhead or apron because these are all built into the boat during the normal building process. Allowance has to be made during the translation of the section drawings/offsets for the skin thickness and it is also common practice to mark on each frame, or the support legs for each frame, both the sheer line and also a main reference line. In this way the main ref. line will be parallel with the floor once the frames have been erected and the sheer line markings can be used to transfer a rough guide of the sheer position to the finished hull. Fig 3 shows a typical frame section with centre line, sheer and main reference lines marked.

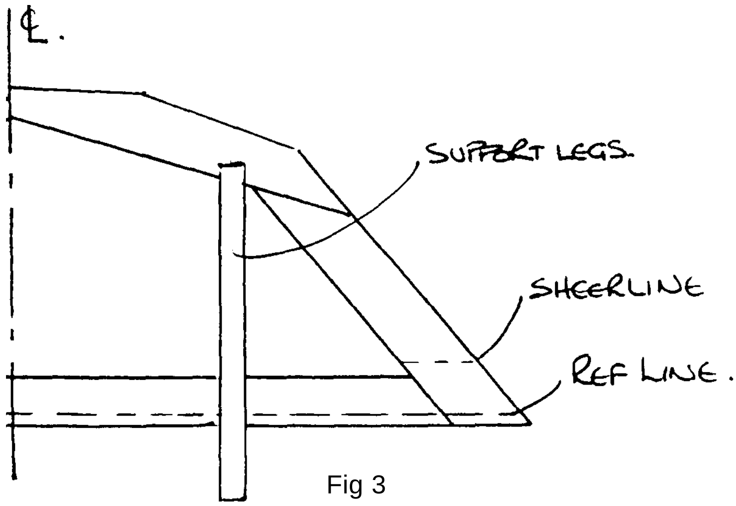


Fig 3

Fig-4 shows a side elevation of all of the frame stations set up in place.

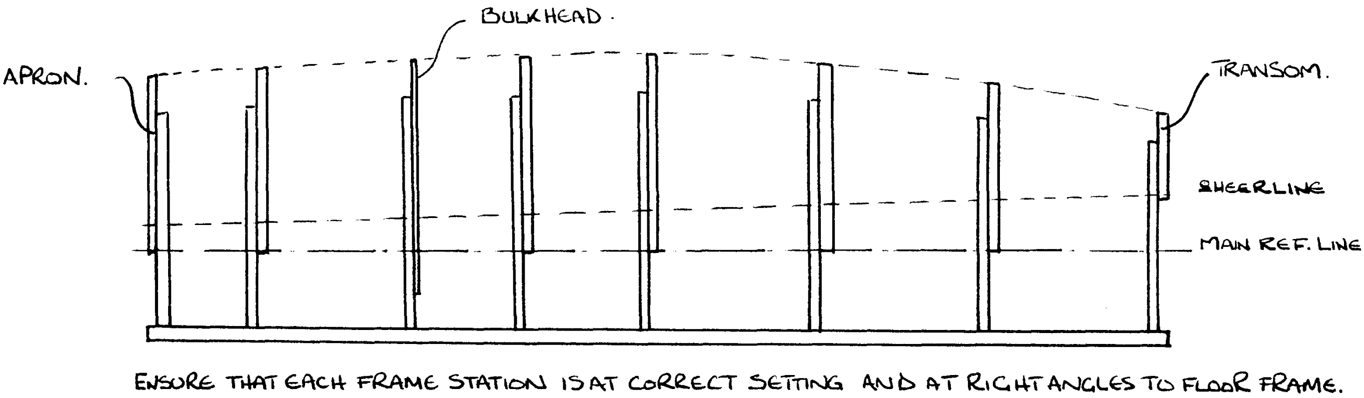


FIG. 4 SIDE ELEVATION OF MOULD.

It is essential that all of the frames are set up in position both accurately and securely – cross brace where necessary and check that all cross sections are squared and perpendicular. With the aid of the centre line marked on each frame it is possible to stand back and ensure that every frame is aligned. The further that you can stand from the framework the better. A good indication of the fairness of the set up can be obtained at this stage.

It is not necessary to bevel the edges of the frames with the exception of course of the transom, bulkhead and apron, with the others they can be moved forwards or backwards from their respective station dependent on whether the boat is increasing or decreasing in width. A glance at figure 5 will clarify the situation.

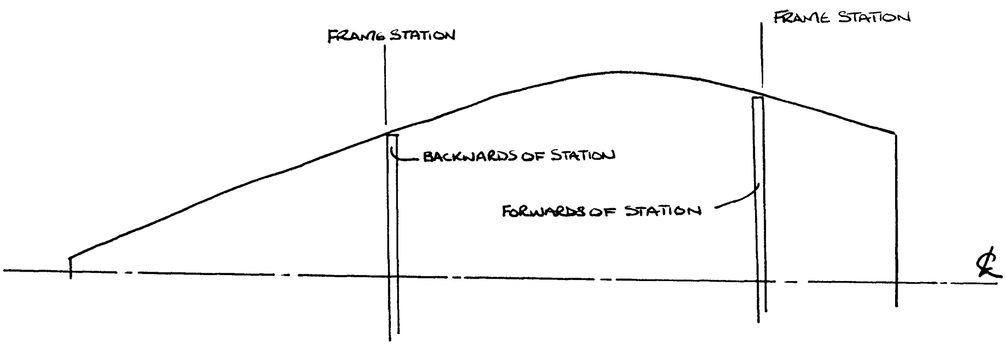


FIG. 5

There is a division of opinion among amateur builders as to whether the centre board case should be incorporated into the frames and the boat built around it or whether to fit the case after the hull has been taken from the frames. I personally favour the latter as it makes for simpler frames but care should be taken during the fitting operation to ensure that the shape of the hull does not alter during the fitting operation: this will be dealt with in a later section.

4. Glues & Resins

4.1 Types of resin

Resins have developed significantly since the 1970s. Epoxy resins are strong and do not take on water although they do degrade if exposed to UV so care must be taken to cover them up with paint or varnish. There is a wide range of fillers which can be added to the resin to change the properties, either making the resin better for filling, bonding or making it harder. The fillers also thicken up the resin and make the resin easier to fillet so that the manufacturing process is more tolerant to gaps. Polyester resins are cheaper than epoxy resins but still have a problem soaking up water and do not have as good strength characteristics. Polyesters are generally only used on trailer cradles and cheaper mass produced boats.

Epoxy resins are available from West and SP systems. There are various types which generally come with slow and fast hardener:

- Finishing – SP105
- Laminating – Ampreg 20
- General purpose use – SP320 or SP106

To set properly the resin should be kept in a certain temperature range – read the manufacturer's instructions but this is generally 15 degrees C to 40 degrees C. So if it is cold outside, try and cover the area using a polystyrene tent or a cloth covering and get a fan heater on the job once you've applied the epoxy. Be careful not to overheat as foam has a tendency to soften and bend or sag.

Care should be taken when mixing. If mixing in a cold environment be careful when heat is applied as the resin will reduce in viscosity and start to run. If it is cold, a top tip is to mix the resin in front of a fan heater just to get it to 30+ degrees. This will ensure that you will add enough filler materials to get it to the correct thickness and it won't run later.

4.2 Glue fillers

For laminating – no filler required.

For filleting – add a combination of micro-balloons (normally purple) and glass bubbles to make the mixture really thick so it spreads well and doesn't sag.

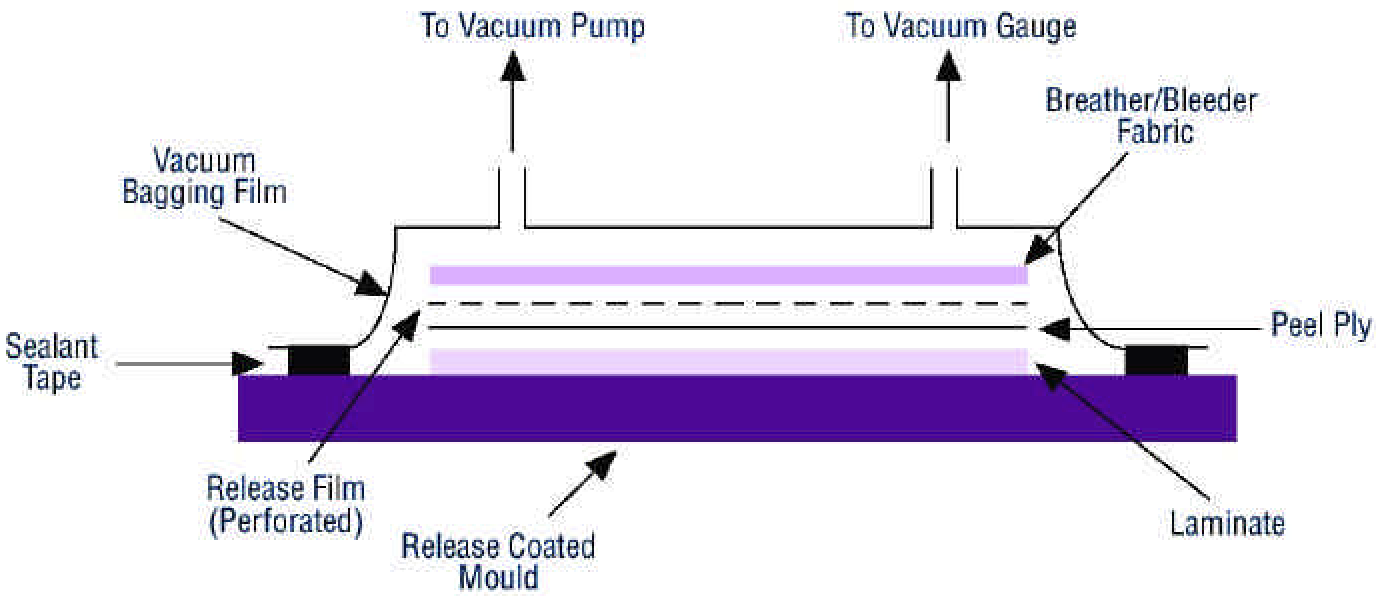
For finishing – use a fine finishing compound which will flow well whilst keeping a smooth finish and not dimpling

For bonding – use micro-fibres which have a slightly woolly feel to them. These absorb the epoxy and keep lots of epoxy in one place.

Colloidal silica can also be added to stiffen a mixture and produce a very hard finish (this makes it harder to sand though)

5. The laminating process

The basic objective is to wet out the cloth, stick it firmly to the foam and remove any excess epoxy in order to keep the weight down.



1. Preparation is key so before you mix any epoxy, cut the carbon or glass cloth to the correct size A neat trick here is to peel away some of the strands near the edge. If you don't then these strands just fall off later and make a mess so removing them early makes it easier to handle the cloth. Then cut peel ply and absorbent cloth to the right size. Cut the vacuum bag to the correct size, do a trial run, then you are ready to mix the epoxy.

2. Apply epoxy to the foam using either a brush or scraper, approximate ratio to mix is 1.5 epoxy to 1 weight of cloth. When the excess epoxy is removed as a result of vacuuming then the ratio should be 1.2 – 1.3 : 1 epoxy to cloth.

3. Lay the cloth and press it onto the epoxy using either a scraper or brush, keep applying pressure and the epoxy will steadily seep through. For large areas a metal slotted roller can be used to speed this up.

4. When the cloth seems reasonably wet out apply the peel ply and press on more, the best finish is achieved when the peel ply is also wet through so where it is dry apply some extra epoxy

5. When the peel ply is wet apply the absorbent cloth over the top then the vacuum bag

6. It is best to wait until the epoxy is starting to gel before applying the vacuum otherwise there is a risk that too much epoxy is removed.

7. When the vacuum is on, wait and see whether you get a decent vacuum. Listen for air leaks and try to seal these. The best way to get a seal is using the black tacky tape which is really sticky on both sides. If you have a good laminating surface and good bag then you can use normal packing tape. But for fiddly joints; particularly corners and where the vacuum pipe exist the bag, the tacky tape rules!

8. All air leaks fixed? Then it is time to apply the heat, 40 degrees is good. Fan heaters and polystyrene makeshift tents can help here.

9. If you leave your epoxy pot in with the job then you know when it is set.

Top tips

- Lay cloth fibres at 45 degrees to a corner to make it easier to go over
- Be careful where the end of the vacuum pipe ends up, it can start to suck the cloth into the pipe. It is general best to wrap lots of the absorbent cloth around the end to spread the vacuum.

6. Finishing

Hi-building: Epoxy "Hi-build" can be used to rapidly build up thickness on a surface and cover any imperfections. This sets quickly and overcoats can be applied within a few hours. It is also relatively low density and is fairly easy to sand back to a smooth surface. Expect to put a lot of this on and sand it off again.

Filling: Hi-build is great for minor blemishes but making an epoxy filler mixture is best for bigger blemishes. Polyester fillers like plastic padding can be used. Whilst these set quickly and are easy to sand they probably won't last as long as an epoxy filler.

Painting: Sand with 400+ grit sandpaper. Hoover and let the dust settle. Wipe over the surface with thinners and allow to evaporate. Apply an undercoat then the top coat. Best results are achieved by applying the paint in two directions at 90' and then smoothing off in one direction.

Varnishing: See rules for painting above**.** If you've used epoxy or polyester then best to use a 2-part varnish. Single part varnish tends to fall off very quickly.

7. Fitting out

If you are building in foam then bond in wood pads where you plan to put fittings as otherwise they will pull through and you risk denting or cracking the foam. Bolt fittings where you can for security and use large penny washers to spread the loads. If you have a bit of time on your hands, then the best way to keep a boat smart is to fit Tuffnel pads where the ropes run to avoid wear. Where holes are drilled into the foam then seal using either silicon sealer or bond fittings in with epoxy. Where a fitting takes a lot of load then you can drill out a hole over-size and fill with epoxy to spread the load, then drill out to the correct size.